Block 1
File

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Nov. 17, 1981

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MINN. POLLUTION
CONTROL AGENCY

Rick Ferguson
Minnesota Pollution Control Agency
1935 W. County Rd. B2
Roseville, MN 55113

Dear Rick:

Enclosed is a brief review and evaluation of the possibility of human exposure to PNA's resulting from homes being built on the site and from contact with the soil in yard or park areas.

As you can see, vapor flux is probably not a concern. Dust could cause exposure, but is probably negligible compared to direct injestion by children. I understand that some of the area has been covered with topsoil; in addition, areas where visibly contaminated lumps of soil occur should also be covered to prevent exposure.

Please review the attached and let me know if I can be of further assistance. Do not hesitate to contact me.

What progress has been made on arranging the trench sampling on the northern part of the site? Mike asked me to be present or to send one of my people. Please keep me posted.

Sincerely yours,

K. W. Brown

KWB/tg
Encl.-1
cc Mike Kosakawski
Marc Hult

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Potential Pathways of Human Exposure to Polynuclear Aromatic Hydrocarbons at the Abandoned Reilly Chemical and Tar Site

by

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INTRODUCTION

Before additional housing is built on the abandoned Reilly Chemical and Tar site, there are three pathways in addition to drinking water by which polynuclear aromatic hydrocarbons (PNA) could affect human health that must be considered. The problem of PNAs in groundwater used for drinking has already been studied extensively. The three other potential pathways which have not been given due consideration are:

1) volatilization of PNAs from the surface of the soil and possible vapor build-up in homes,
2) inhalation of PNAs adsorbed to dust particles suspended in the air, and
3) direct ingestion of PNAs by children especially those with pica, a common disease that causes children to eat soil.

PNAs AS VAPOR

Polynuclear aromatic hydrocarbons have high melting points coupled with low vapor pressures and so would not be expected to be very volatile. In addition, PNAs are strongly adsorbed to soil particles. The melting points, vapor pressures, and saturation vapor densities for certain PNAs are listed in Table 1. Also listed are the concentrations of PNAs in the air of a northern industrialized city (Detroit, Michigan). As the Table shows, the saturation vapor density for benzo[a]pyrene is very close to the background level. The saturation vapor densities for benzo[g,h,i]perylene and benzo[k]flouranthene are well below the observed background levels. This indicates that the PNAs measured in the air probably do not occur as vapor, but instead occur as suspended particulates. Suess (1975) reported that PNAs released into the

Table 1. **Factors Affecting the Vapor Flux of Certain PNAs, and Background Levels of PNAs in Air**

Compound	Melting Point, °C*	Vapor Pressure, torr*	Saturation Vapor Density, ng/m^3†	Background Levels of PNA in Air# ng/m^3 (summer-winter)
benzo[a]-pyrene	179	5×10^{-9}	6.89×10^{1}	$6.0\text{-}3.1 \times 10^{1}$
benzo[g,h,i]-perylene	222	10^{-10}	1.50	$9.5\text{-}3.3 \times 10^{1}$
dibenz[a,h]-anthracene	270	10^{-10}	1.52	
chrysene	256	10^{-11} to 10^{-6}	1.25×10^{-1} to 1.25×10^{4}	
phenanthrene	101	6.8×10^{-4}	6.63×10^{6}	
anthracene	216	1.95×10^{-4}	1.90×10^{6}	$4.0 \times 10^{-1}\text{-}2.0$
pyrene	150	6.85×10^{-7}	7.57×10^{3}	$2.8\text{-}3.6 \times 10^{1}$
acenaphthylene	92	10^{-3} to 10^{-2}	8.33×10^{6} to 8.33×10^{7}	
fluorene	116-117	10^{-3} to 10^{-2}	6.35×10^{6} to 6.35×10^{7}	
benzo[k]-fluoranthene	217	9.59×10^{-11}	1.32	$4.9\text{-}2.0 \times 10^{1}$
TOTAL PNA				3.24×10^{1}-1.464×10^{2}

* EPA, 1980.

† Calculate by K. W. Brown & Associates.

EPA, 1975.

atmosphere are always associated with aerosols of various types and sizes. Also, in studies of aquatic systems, volatilization was determined to be a relatively unimportant transport process for PNAs (EPA, 1979 and Southworth, 1979).

PARTICULATE PNAs

As mentioned in the previous section, PNAs present in the atmosphere are most likely associated with particulate matter. The general distribution of these compounds is largely governed by meteorological conditions (Suess, 1975). Average ambient concentrations for PNAs in the United States are (EPA, 1980):

Benzo[a]pyrene	0.5 ng/m^3
Carcinogenic PNA	2.7 ng/m^3
Total PNA	1.09×10^1 ng/m^3

Concentrations in urban air can be as much as 100 times higher than in non-urban air and concentrations during the winter may be 100 times higher than summer (Suess, 1975 and WHO, 1973). Values for total atmospheric PNA concentration for Detroit range from 3.24×10^1 nanograms per cubic meter of air in summer to 1.464×10^2 nanograms per cubic meter of air in winter (EPA, 1975).

Since PNAs are associated with particulate matter, there could be a potential problem with dust arising from the soil at the Reilly Tar site. Air sampling should be conducted to determine the background levels of atmospheric PNAs during different seasons for the urbanized area. Air sampling near the site can be compared with the background levels determined for the area. If the concentration near the site significantly exceeds the background levels, then further clean-up to reduce PNAs associated with particulates may be needed.

DIRECT INGESTION OF PNAs

To thoroughly evaluate the health risks posed by residential development at the abandoned Reilly Tar site, the direct ingestion of soil containing PNAs by children must be considered. The average child ingests 50 milligrams of soil per day directly through hand to mouth play. A child with pica, a common childhood disease, ingests an average of 2 grams of soil per day (Chaney, 1981). Contaminated surface soils at the site contain up to 2,600 micrograms of total PNAs per gram of soil (data from 4-1/2 foot depth, National Biocentric, Inc. report). This means that a child with pica would ingest approximately 5,200 micrograms of total PNAs per day and an average child would ingest 130 micrograms per day from soil. This would be in addition to, and considerably higher than, the PNA exposure from other sources, such as drinking water, food, and air (Table 2).

Table 2. Estimated Human Exposure to PNA From Various Media

	Estimated Exposure (μg/day)		
Source	benzo[a]pyrene	carcinogenic PNA*	Total PNA
Water	0.0011	0.0042	0.027
Food	0.160-1.6		0.251-1.600
Air	0.005-0.0115	0.03-0.046	0.164-0.251
TOTAL	0.166-1.6		1.6-16

* total of benzo[a]pyrene, benzo[j]fluoranthene and indeno[1,2,3-cd]pyrene, no data available for food.

EPA, 1980.

The maximum total PNA dose that children would be exposed to is shown in Table 3. Values for ingestion of PNAs from water and food are taken from Table 2. To determine the amount of PNA intake from the air, the concentration was

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multiplied by 15 m^3 (the average intake of air by humans ranges from 15-23 m^3/day, EPA, 1980). The concentration used to calculate a worst-case situation was 1.464×10^2 ng/m^3 (the winter level for Detroit, from Table 1). For a more average situation the value from Table 2 was used. The quantity of PNA directly ingested with soil was calculated earlier.

Table 3. Total PNA Exposure for Children

	Estimated exposure, average child (μg/day)		Estimated exposure child with pica (μg/day)	
Source	Average situation	Worst-case situation	Average situation	Worst-case situation
Water	0.027	0.027	0.027	0.027
Food	1.600	1.600	1.600	1.600
Air	0.251	2.196	0.251	2.196
Soil	130.0	130.0	5,200.0	5,200.0
TOTAL PNA	131.878	133.823	5,201.878	5,203.823

As the table shows, the estimated daily exposure to total PNAs from all sources for the average child living at the proposed site would be .131 to .138 milligrams and for a child with pica the daily exposure would be 5.201-5.203 milligrams. This is significantly higher than the average daily intake for man of .0016-.016 milligrams reported by EPA (1980).

Studies by Neal and Rigdon (1967) showing the cancer incidence in mice when fed rations containing from 0.001 to 0.25 milligrams of benzo[a]pyrene per gram of food were used by EPA to develop a carcinogenic potency factor for humans. This level, 11.53 mg/kg food/day, was calculated to keep the individual lifetime risk of developing tumors below 10^{-5} (EPA, 1980). In their calculations, EPA assumed the total daily food consumption for man for all types of food was 1,600 grams. The maximum intake of food for a child might reasonably be set at 500 grams per day. Thus an average child would ingest 0.263 to 0.276 mg/kg food/day, while a child suffering from pica would be expected to be exposed to a dietary concentration of total PNAs of 10.4 mg/kg food/day. Thus it would appear that soil ingestion by an average child would result in probabilities considerably below the 10^{-5} probability level; however, consumption of soil by children with pica would approach that level of exposure for total PNAs. Only a fraction of the PNAs in the soil would have the same carcinogenic activity as benzo[a]pyrene so that while some risk is apparent, the probability of an individual child being affected would be less than 10^{-5}, assuming relatively homogeneous soils with PNA concentrations not exceeding 2,600 micrograms per gram of soil.

CONCLUSIONS

Three potential pathways by which PNAs could affect human health at the abandoned Reilly Tar site have been explored. The potential for vapor build-up in buildings at the site seems slight. Particulate PNAs could potentially be a problem in the air, however without specific air sampling data it is difficult to predict whether the PNAs at the site would cause ambient air concentrations to be higher than average for a northern industrialized city. If the site was covered with clean fill, the problem of particulate PNAs would be greatly reduced.

At the Reilly Tar site, a child with pica might reasonably be expected to receive a total daily PNA exposure which is significantly higher than the daily exposure for the average population, but below the 10^{-5} probability level for lifetime cancer risk, provided surface soils are relatively homogeneous and contain no more than 2,600 micrograms of total PNAs per gram of soil. However, the soils in some areas of the site occur as lumps which are visibly contaminated with waste and these lumps are likely to contain much higher concentrations of PNAs. On these areas, the top foot of soil should be removed or the area should be covered with one foot of clean fill material to keep the children from coming into direct contact with highly contaminated soils.

REFERENCES

Chaney, R. 1981. Personal Communication.

Neal, J. and R. H. Rigdon. 1967. Gastric Tumors in Mice Fed Benzo[a]pyrene: A Quantitative Study. Texas Rep. Biol. Med. 25:553-557.

Southworth, G. R. 1979. The Role of Volatilization in Removing PAH From Aquatic Environment. ORNL, B. Env. Contam. and Tox., Vol. 21, No. 4-5, p. 507.

Suess, M. J. 1975. The Environmental Load and Cycle of Polycyclic Aromatic Hydrocarbons. Presented at the International Conference on Environmental Sensing and Assessment, Las Vegas (Sept. 14-19, 1975).

U.S. Environmental Protection Agency. 1975. Scientific and Technical Assessment Report on Particulate Polycyclic Organic Matter (PPOM). EPA-600/6-75-001.

U.S. Environmental Protection Agency. 1979. Water-Related Environmental Fate of 129 Priority Pollutants, Volume II, EPA-440/4-79-029b.

U.S. Environmental Protection Agency. 1980. Ambient Water Quality Criteria for Polynuclear Aromatic Hydrocarbons. EPA-440/5-80-069.

World Health Organization, International Agency for Research on Cancer. 1973. IARC Monographs on the Evalution of Carcinogenic Risk of the Chemical to Man: Certain Polycyclic Aromatic Hydrocarbons and Heterocyclic Compounds, Volume 3. (IARC, Lyon).